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(54) **Filter for separating contaminant material from a fluid**

(57) A cartridge-type filter, which is especially suitable for separating radioactive particles from reactor cooling water in nuclear power plants, comprises a filter housing 5 having an inwardly-facing flange 16 which is designed as a valve seat. A filter cartridge 10 is joined to an outwardly-facing ring 20 which is designed to sealingly cooperate with the flange 16 of the filter housing and freely suspend the cartridge in the filter housing. The filter housing 5 is divided by the ring 20 and the cartridge 10 into two separate spaces 22, 23. Contaminated fluid is led to the space 22 via a conduit 7 and filtered fluid is led away from the space 23 via a conduit 8. When used in a nuclear power plant, the conduits 7 and 8 are connected into the reactor cooling water circuit, and part of the reactor cooling water is conducted continuously through the filter circuit, which is parallel to the main water flow.

FIG. 3

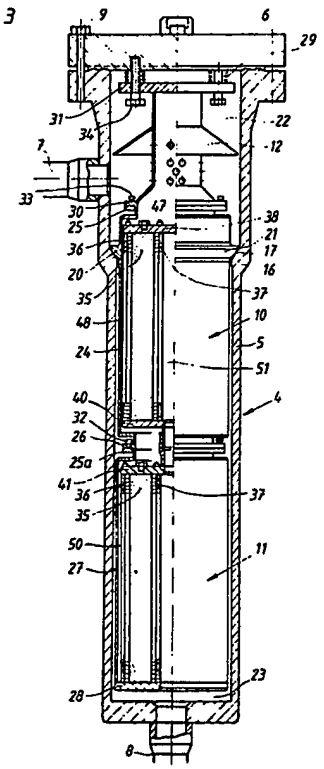

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FIG. 1

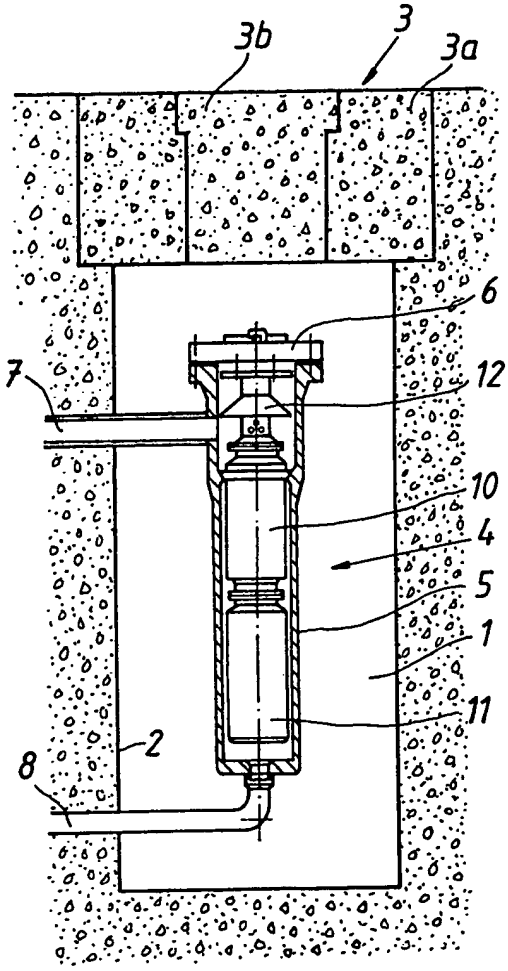

FIG. 2

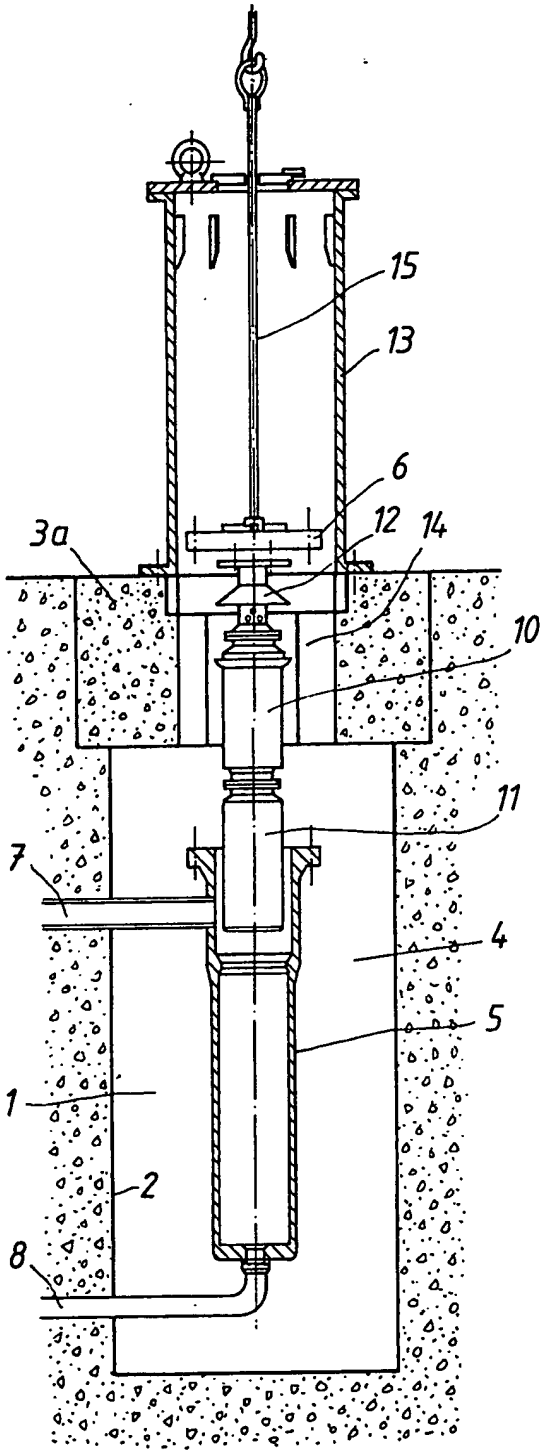

FIG. 3

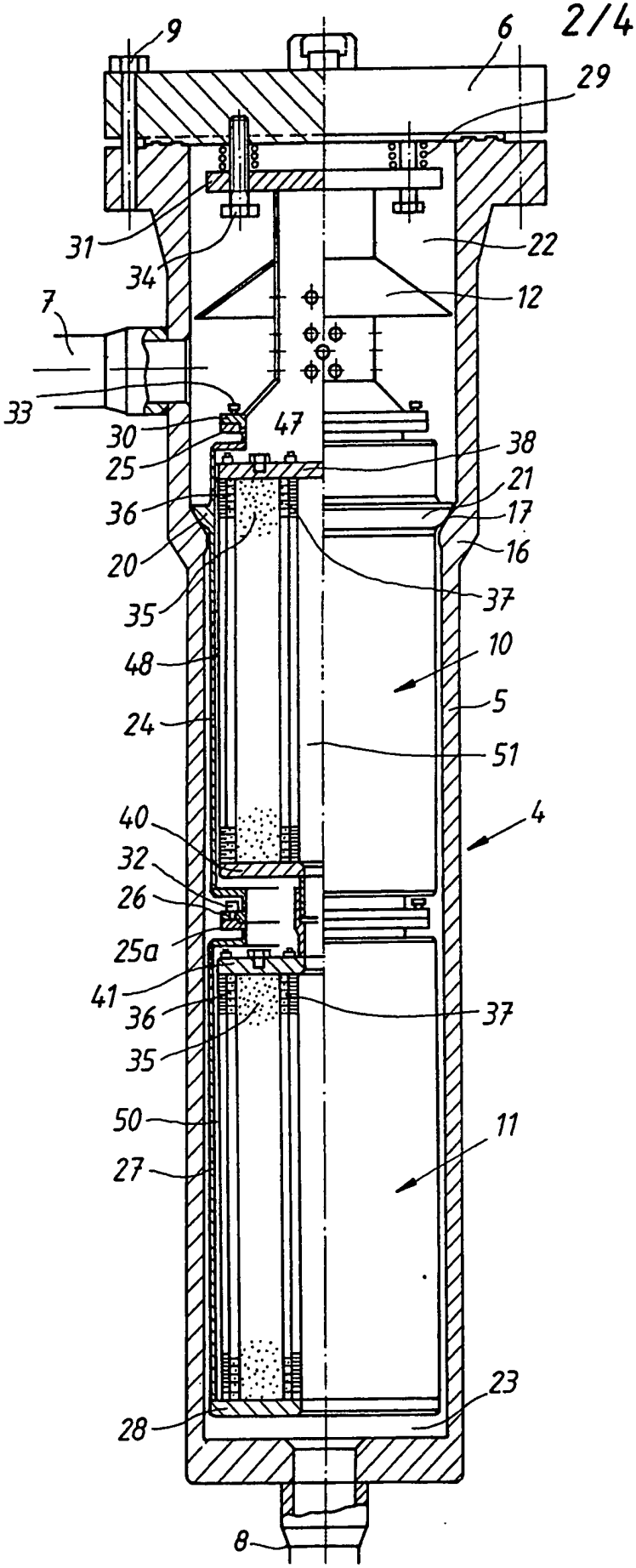
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FIG. 4

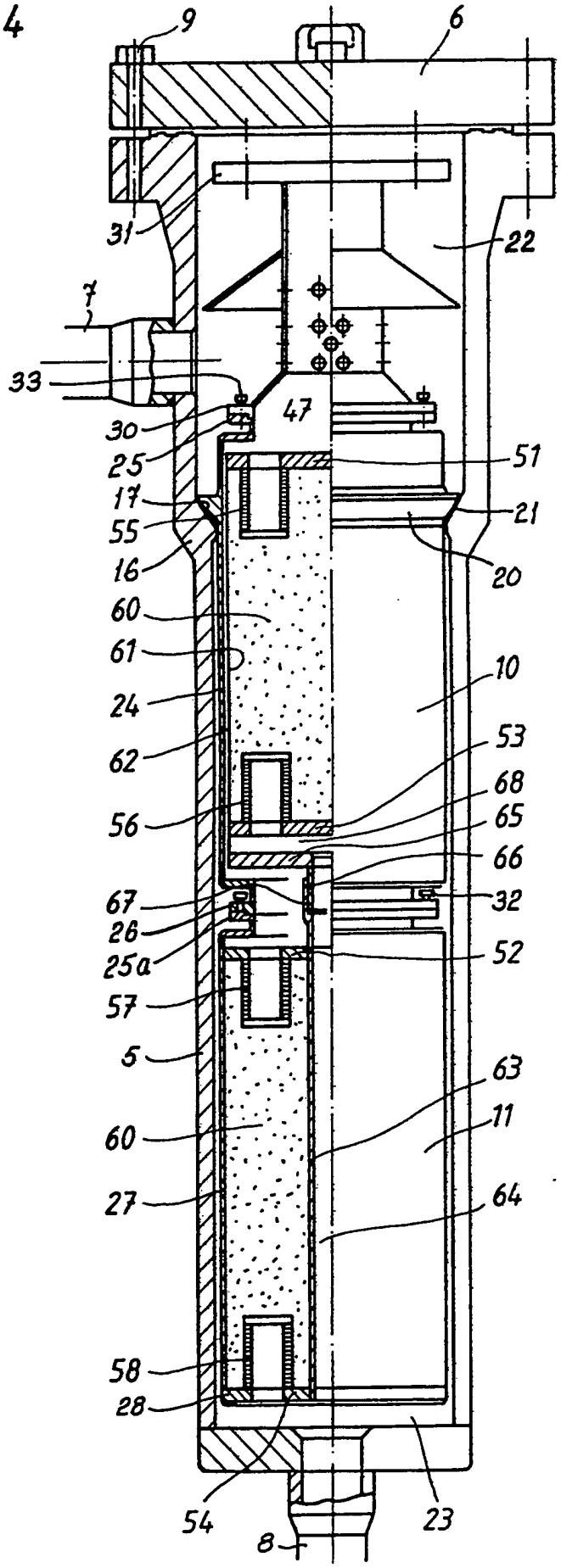
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FIG. 5

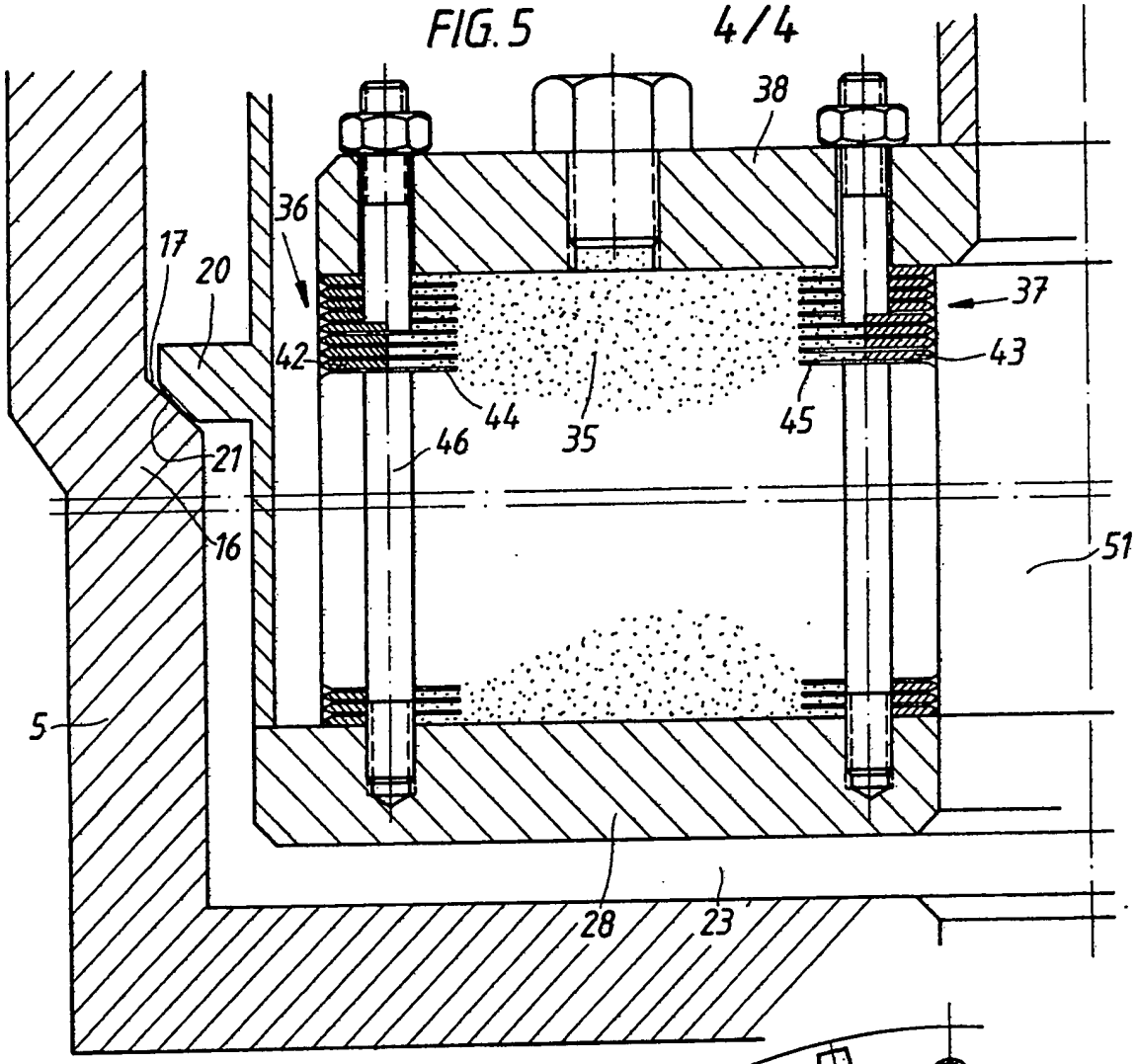
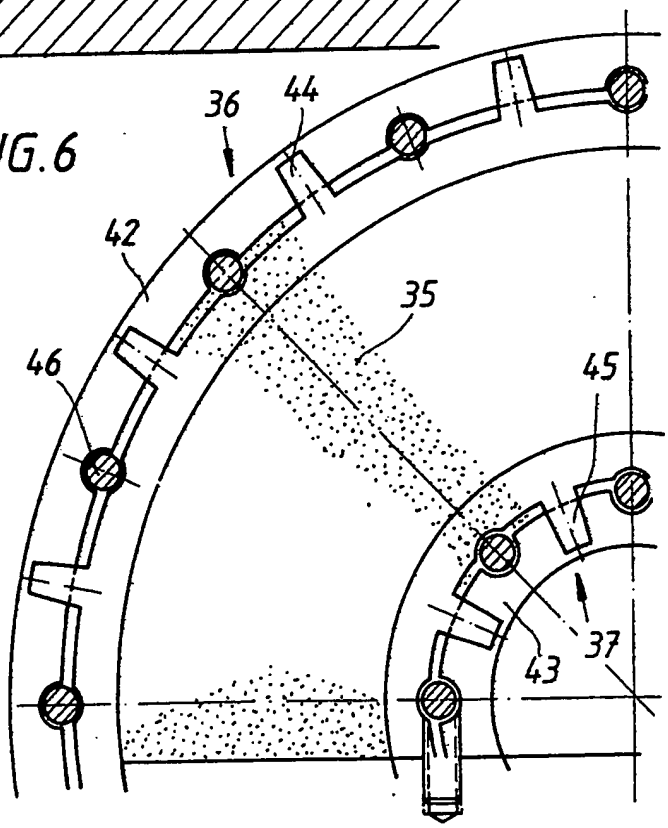


FIG. 6



SPECIFICATION

Filter for separating contaminant material from a fluid

This invention relates to a cartridge-type filter for separating contaminant material from a fluid. In particular, but not exclusively, it relates to such a filter for separating particulate contaminant material from the circulating cooling water of a nuclear power plant.

Chemical reactions in nuclear power plants lead to the formation of substances, especially oxides, on the surface of various constructional elements, for example on the inner surface of the reactor vessel, in conduits, valves and pumps and on the surface of components included in the reactor core. Flow and abrasion result in these substances loosening from the constructional elements in the form of tiny particulate material which contaminates the cooling water.

Because the contaminant particular material is formed and circulates in an environment with high radioactivity, radioactive isotopes are formed in the particulate material. For example, from an alloying material like cobalt, a radioactive isotope Co 60 may be formed. This means that a filter containing a considerable quantity of separated material is highly radioactive and that the handling of it involves special problems because of the radiation emitted by the filter material. The filters must be surrounded by radiation protection, and exchange of filter material must take place by remote operation, since the radiation level may exceed 1000 mrem/h in the immediate vicinity of the filter.

The present invention aims to provide a filter in which exchange of the filter material may take place in a simple manner despite a high level of radiation.

According to the invention, a cartridge-type filter for separating contaminant material from a fluid, comprises an elongate tubular housing with its longitudinal axis disposed substantially vertically and an open or openable upper end, an inwardly-directed flange or shoulder in the upper portion of the housing serving as a valve seat, and a filter cartridge, containing contaminant-capturing material, freely suspended in said housing by means of a ring which sealingly engages with said flange or shoulder, said ring and filter cartridge dividing the filter housing into first and second separate spaces connected, respectively, to an inlet for the contaminated fluid and an outlet for filtered fluid.

In use of a filter in accordance with the invention, the filter cartridge can be easily placed in or removed from the filter housing by simple remote controlled means. When employed for filtering contaminant material from the cooling water of a reactor, the contaminated water is supplied to said first space, which suitably is in the upper portion of the housing, and cleaned water is collected in said second space, which is suitably in the lower portion of the housing, and is returned to the reactor vessel. The filter is suitably included in a circuit parallel to the main water flow of the reactor, so that only a minor part of the flow passes through this cleaning circuit.

Several filter cartridges may be placed in one filter housing, with the cartridges connected in series or in parallel. Several filter housing may be included in one filter group, with the housings connected either in parallel or in series. In the filter cartridge(s), the filter material may be placed between strainers on the inlet and outlet sides. For example, a cartridge may be constructed with two concentric, annular gap strainers between which an annular filter bed is located, through which the contaminated fluid flows radially. Alternatively, it may be provided with strainers at its ends, and the contaminated water will then pass axially through the filter bed positioned between the strainers. The filter bed may consist of metal wire clippings. The contaminants are absorbed to a considerable extent on the surface of the filter bed material.

The filter housing may be closable at its upper end by a lid. The filter cartridge or cartridges may be joined to this lid in such a way that when the lid is lifted, the cartridge or cartridges are lifted together with the lid. During lifting by a lifting device and during transportation in a radiation protection device, the lid constitutes excellent radiation protection against upwardly-directed radiation. To bring about an increase of the contact force between the flange or the shoulder in the filter housing and the co-acting ring, which supports the cartridge or cartridges, a stack of springs may be arranged between the lid and the filter cartridge.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which

Figure 1 is a schematic sectional view showing a filter forming part of a nuclear power plant,

Figure 2 is a view similar to Figure 1 illustrating removal of filter cartridges from the filter,

Figures 3 and 4 are sectional views of two different embodiments of filters in accordance with the invention,

Figure 5 is a view, on an enlarged scale, of part of Figure 3, and

Figure 6 is a horizontal section, on an enlarged scale, through a filter cartridge of the filter shown in Figure 3.

Referring to Figures 1 and 2, the numeral 1 designates a space defined by concrete walls 2 and a lid 3 consisting of an outer annular concrete portion 3*a* and an inner concrete portion 3*b*. The space 1 accommodates a filter unit 4. This unit comprises a cylindrical filter housing 5 and a detachable lid 6. The filter housing is connected to the primary cooling water system of a nuclear reactor (not shown) by a supply conduit 7 and a return conduit 8. Since the filter unit 4 communicates with the primary cooling water system of a reactor, the filter unit must be dimensioned for the same pressure as said system, usually about 70 bar in a boiling reactor. It may also be suitable to adapt the filter unit to the steam temperature, which is about 300°C. Two filter cartridges 10 and 11 are mounted in the filter housing. The upper cartridge 10 is joined to an inlet portion 12 for control of the direction of the water flow at the inlet of the cartridge 10. The inlet portion 12 is joined to the lid 6. When withdrawing the cartridges 10 and

11, the lid portion 3*b* is removed and a radiation protection device 13 is applied, as shown in Figure 2, over the opening 14; a rod 15 is connected to the lid 6 and the whole unit consisting of the lid 6, the inlet portion 12 and the cartridges 10 and 11 are lifted up into the radiation protection device 13. The lid 6 provides radiation protection against upwardly-directed radiation. The device 13 with its contents is removed, the cartridges 10 and 11 and the inlet portion 12 are separated, whereupon the cartridges 10 and 11 may be cast into concrete and be deposited in a conventional manner.

Referring now to Figures 3, 4 and 5, the upper portion of the filter housing 5 has a larger diameter than the lower portion. At the diameter transition there is formed a shoulder 16, which is formed with a frusto-conical surface 17 like a valve seat. The upper cartridge 10 is provided with a ring 20 having a spherical surface 21 intended to cooperate in a sealing manner with the surface 17 of the shoulder 16. The surfaces 17 and 21 are in direct contact and sealing is obtained between two metallic surfaces. By means of this ring 20 and the cartridge 10, the filter housing is divided into a first space 22 in the upper portion of the housing 5 and a second space 23 in the lower part of the housing. The cartridges 10 and 11 are suspended from the ring 20 and hang freely in the filter housing 5. By this design of the surfaces 17 and 21, which co-act with each other and seal against each other, the filter cartridges 10 and 11 are automatically centered upon insertion, and a uniform, reliable contact between the surfaces, and thus a reliable, good seal, is obtained. By reducing the acute angle of the frusto-conical surface 17, the surface pressure may be increased to a level desirable to obtain good sealing.

The supply conduit 7 opens into the upper space 22 and the return conduit 8 opens into the lower space 23. The upper cartridge 10 comprises a sleeve 24 having flanges 25 and 26. The lower cartridge 11 comprises a sleeve 27, a flange 25*a* and an annular bottom portion 28. The inlet portion 12 is provided with flanges 30 and 31. The cartridges 10 and 11 are connected by the flanges 26 and 25*a* and bolts 32. The inlet portion 12 and the cartridge 10 are connected by the flanges 25 and 30 and bolts 33. The inlet portion 12 is connected to the lid 6 by the flange 31 and bolts 34 (shown in Figure 3 only). The bolts 32 and 33 are welded to the flanges 25*a* and 25, respectively, the flanges 26 and 30 being provided with openings for the bolt heads and slots for the bolt shanks. The bolt heads are inserted through the openings, whereafter the cartridges are turned so that the bolt shanks enter into the slots. The connection devices are thus of a bayonet type. The lid 6 is secured to the housing 5 by bolts 9 and between the lid 6 and the flange 31 there are springs 29 (shown in Figure 3 only) which press the entire cartridge unit with increased force against the surface 17.

In the filter shown in Figures 3, 5 and 6, filter material 35 is placed between two annular concentric strainers 36 and 37, respectively, between a plate 38 and a ring 40, and between a ring 41 and the bottom 28, respectively. A s is shown in Figures 5 and 6, the strainers consist respectively of rings 42 and 43 and of spacers 44 and 45. These rings 42 and 43 and spacers 44 and 45 are held together by bolts 46. The thickness of the gap is chosen somewhat smaller than the grain size of the filter material 35. If wire clippings with a length of 0.4 mm and a diameter of 0.4 mm are used, there are suitably used spacers with a thickness of 0.2 mm.

In a filter according to Figures 3, 5 and 6, water flows from the inlet conduit 7 into the space 22 and thence into the inlet portion 12, a space 47 and down into gaps 48 and 50 between the tubes 24 and 27 and the strainers 36, radially through the filter material 35 into a central space 51, down into the space 23 and out through the return conduit 8.

In the embodiment of the filter shown in Figure 4, lids 51 and 52 and bottoms 53 and 54 comprise strainers 55, 56, 57 and 58, respectively. Filter material 60 is present between the strainers. The lid 51 and the bottom 53 are connected by a sleeve 61 with a gap 62 between this sleeve 61 and the sleeve 24. The lid 52 and the bottom 54 are connected by the sleeve 27 and a sleeve 63, between which is an annular space for the filter material 60. The sleeve 63 defines a central axial channel 64. A bottom 65 in the filter cartridge 10 is provided with a sleeve 66 and the lid 52 with a muff 67, so that the cartridges 10 and 11 are connected together and a connection is obtained between a space 68 in the cartridge 10 and the channel 64 through the cartridge 11.

Water flows through the strainer 55, axially through the filter material 60 and the strainer 56 to the space 68 and thence through the channel 64 to the space 23. Another part of the water flows from the space 47 through the gap 62 down to the cartridge 11, through the strainer 57, the filter material 60 and the strainer 58 to the space 23.

Of course, it is possible to use filter cartridges of different shapes and different materials compared with those shown in the drawings. Thus, for example, the filter cartridges may be constructed as plane filters of different kinds.

CLAIMS

1. A cartridge-type filter for separating contaminant material from a fluid, comprising an elongate tubular housing with its longitudinal axis disposed substantially vertically and an open or openable upper end, an inwardly-directed flange or shoulder in the upper portion of the housing serving as a valve seat, and a filter cartridge, containing contaminant-capturing material, freely suspended in said housing by means of a ring which sealingly engages with said flange or shoulder, said ring and filter cartridge dividing the filter housing into first and second separate spaces connected, respectively, to an inlet for the contaminated fluid and an outlet for filtered fluid.

2. A filter according to claim 1, in which there is metallic contact between said flange or shoulder and said ring.

3. A filter according to claim 1 or 2, in which said flange or shoulder has an inwardly-inclining surface.

4. A filter according to claim 3, in which said surface is frusto-conical.

5. A filter according to claim 3 or 4, in which said ring is formed with a spherical surface intended to

cooperate with said surface.

6. A filter according to any of the preceding claims, in which the upper end of the housing is closed by a removable lid which is provided with gripping means for lifting devices, the lid and the filter cartridge being joined together so that the cartridge accompanies the lid when the latter is lifted from the housing.

7. A filter according to claim 6, in which the lid and the filter cartridge are permanently joined to each other in such a way that a certain axial movement between the lid and the filter cartridge is possible.

8. A filter according to any of the preceding claims, in which a plurality of filter cartridges are included in one filter housing, which filter cartridges may be parallel- or series-connected.

9. A filter according to claim 8, in which said filter cartridges are connected in parallel or in series.

10. A filter according to any of the preceding claims, in which the or each filter cartridge comprises two concentric gap strainers between which there is an annular space with a filter bed through which the contaminated fluid flows radially.

11. A filter according to any of claims 1 to 9, in which the or each filter cartridge is provided at its ends with gap strainers, the space between the strainers containing a filter bed though which the contaminated fluid flows axially.

12. A filter according to claim 10 or 11, in which the filter material in the filter bed consists of wire clippings.

13. A filter group comprising a plurality of the cartridge-type filters claimed in any of the preceding claims, which filters are connected in series or in parallel.

14. A cartridge-type filter connectible into the reactor cooling water circuit of a nuclear power plant for separating radioactive particles from the cooling water, said filter comprising a housing with an opening at the top, which may be closed by a lid, and the upper portion of the filter housing being designed with an inwardly-directed flange or shoulder which is made in the form of a valve seat, and a filter cartridge with particle-capturing filter material, said filter cartridge (or a unit supporting the filter cartridge) being formed with a ring which is designed to sealingly engage with said flange or shoulder and freely suspend the filter cartridge in the housing, said ring, together with the filter cartridge, dividing the filter housing into two separate spaces which are connectible with said cooling water circuit by way of separate conduits.

15. A nuclear power plant comprising a reactor, a cooling water circuit for the reactor, and a filter as claimed in any of the preceding claims connected in said cooling water circuit for filtering contaminant particles from the cooling water.

16. A cartridge-type filter constructed and arranged substantially as herein described with reference to Figures 3, 5 and 6 or Figure 4 of the accompanying drawings.

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